

SOCIAL CONCEPTS OF MONKEYS

Inaugural-Dissertation

zur Erlangung der Philosophischen Doktorwürde
vorgelegt der
Philosophischen Fakultät II
der Universität Zürich

von

VERENA DASSER
von Thalwil ZH

Begutachtet von den Herren
Prof. Dr. Hans Kummer
Prof. Dr. Emil W. Menzel

Zürich 1987
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Contents

Dank.....	3
Einführung und Zusammenfassung.....	4
Slides of group members as representations of the real animal.....	7
Abstract.....	7
Introduction.....	8
Method.....	10
1.The simultaneous discrimination procedure: procedure and results.....	13
2.The matching-to-sample procedure:procedure and results.....	14
Discussion.....	18
References.....	21
Acknowledgements.....	22
Mapping a Social Concept of Monkeys.....	27
Abstract.....	27
Method.....	29
Results.....	35
Discussion.....	36
References.....	40
Acknowledgements.....	42
Dominance: A monkey's view.....	45
References.....	50
Mother-offspring pairs, siblings, and matriline membership.....	51
Method.....	52
Results.....	54
Discussion.....	55
References.....	57
Curriculum vitae.....	59



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Dank

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Zum Gelingen dieser Studie am meisten beigetragen haben meine Versuchstiere Rini und Riche. Sie seien deshalb an dieser Stelle nochmals besonders erwähnt. Beim Arbeiten mit den Affen in der Station Bockengut, bei den nötigen Stallumbauten und den technischen Einrichtungen halfen mit Kollegen, Mitarbeiter und Freunde. Ihnen allen danke ich herzlich. Mein besonderer Dank gilt Prof. H. Kummer, der mir ein Lehrer im besten Sinne des Wortes war, und meinen Eltern, die mich in mannigfacher Weise unterstützten.

Einführung und Zusammenfassung

"There is no window to another mind", schrieb W.A. Mason (1976) in einer Besprechung von D.R. Griffin's Buch "The Question of Animal Awareness" in "Science". Und fährt weiter: "Mind...is but a construct, hardly more than a label, really, for complex processes and functions that we are still far short of understanding...". Zweifellos: Dr. Dolittle's Plaudereien mit den tierischen Freunden bleiben eine Wunschvorstellung. Trotzdem ist es mit geeigneten Methoden möglich, einen Zugang zu finden zu dem, was "in den Köpfen der Tiere" vorgeht. In meiner Dissertation versuchte ich sichtbar zu machen, was Javaneraffen (*Macaca fascicularis*) über die soziale Struktur der Gruppe wissen, deren Mitglieder sie sind. Besitzen Affen mentale Abbilder ihrer Sozietät? Wenn ja, wie genau sind diese Abbilder, was bilden sie ab? Sieht ein Affe seine Gruppe als eine ungeordnete Menge von bekannten Einzelindividuen, oder bildet seine innere Vorstellung auch die sozialen Beziehungen der Gruppenmitglieder ab? Sind insbesondere dyadische Dominanz- und Verwandten-Beziehungen nur Konzepte des menschlichen Beobachters oder existieren analoge Affen-Konzepte?

Soziale Beziehungen sind im Gegensatz zu sozialen Interaktionen von keinem Sinnesorgan direkt erfassbar, sondern müssen aus Interaktionssequenzen gefolgert werden. Soziale Beziehungen sind abstrakte Einheiten, sind unabhängig von der Identität der Individuen, die die Beziehungen realisieren. Um Beziehungen erkennen zu können, müssen Affen Beziehungskonzepte besitzen, das heisst Regeln, nach denen Beziehungen kategorisiert werden können.

Solche Beziehungskonzepte wurden bei 2 Affen in dieser Arbeit tatsächlich

nachgewiesen.

Die Versuchstiere (VT) waren Mitglieder einer 40-köpfigen, natürlich gewachsenen Affengruppe und wurden nur für die kurze Dauer einer täglichen Experiment-Sitzung isoliert.

Im ersten Teil der Arbeit wurde nachgewiesen, dass Javaneraffen Gruppenmitglieder auf Farbdias identifizieren können. Die beste Evidenz dafür lieferte ein VT, das Bilder nicht-überlappender Körperteile desselben Gruppenmitglieds einander zuordnen konnte. Die Experimente zur Individuen-Erkennung wurden im Kapitel "Slides of group members as representations of the real animals" beschrieben.

Im zweiten Teil wurden Experimente zum Nachweis sozialer Beziehungskonzepte durchgeführt. Wie in den vorangehenden Experimenten sahen die VT Dias von Gruppenmitgliedern. Das Grundprinzip jedes Experimentes bestand darin, den VT in einer Trainings-Phase anhand der in den Dias abgebildeten Gruppenmitglieder wenige Beispiele von mir bestimmter Beziehungskategorien zu zeigen, und die VT für die Wahl derjenigen Tiere zu belohnen, die eine bestimmte Beziehungskategorie in der Gruppe realisieren. So lernte zum Beispiel eines der VT, das Bild eines Nachkommen dem Bild seiner Mutter zuzuordnen, ein gleichzeitig gebotenes Bild eines alters- und geschlechts-gleichen Nachkommen eines anderen Weibchens aber zu ignorieren. In der anschliessenden Transfer-Phase wurde die Reaktion der VT auf Dias anderer Gruppenmitglieder geprüft. Die VT mussten dabei diejenigen Tiere bezeichnen, die die gleiche Beziehung zueinander haben wie die belohnten Trainings-Tiere. Im erwähnten Beispiel wurden also dem VT in der Transfer-Phase andere Mütter und Nachkommen aus der

Gruppe gezeigt. Das VT ordnete in diesem Experiment beinahe fehlerfrei die richtigen Nachkommen ihren Müttern zu.

Durch ihre weit überzufällig häufigen Richtigwahlen in den Transfer-Phasen anderer Experimente demonstrierte ein anderes VT, dass es über ein Konzept der sozialen Dominanz verfügt, das unserem analog ist, und dass es Geschwister-Beziehungen identifizieren kann. Soziale Konzepte dieser Art wurden bisher weder bei Affen noch bei einer anderen Tierart nachgewiesen.

Die Experimente wurden in den zwei Kapiteln "Mapping a Social Concept of Monkeys" und "Dominance: A monkey's view" sowie im Kapitel "Mother-offspring pairs, siblings, and matriline membership" beschrieben. Tabellen und Abbildungen befinden sich jeweils am Schluss jedes Kapitels.

Besitzen somit Affen die gleichen sozialen Konzepte wie ihre menschlichen Beobachter? Wohl nicht. Die Experimente zeigen aber, dass Affen Beziehungsqualitäten erkennen und vergleichen können, und dass einige ihrer Beziehungskategorien den unseren analog sind.

Slides of group members as representations of the real animals
(*Macaca fascicularis*)

Abstract

Three long-tailed macaques (*Macaca fascicularis*) apparently recognized the identity of group members presented by means of colour slides. After training on a minimum of examples, the subjects correctly identified in unique transfer trials novel views of the stimulus animals used in training. In first trials, one subject matched different face views, and face views with other body parts, of the same animal significantly more often than chance when the animals were group members. Slides of group members can therefore be used as representations of monkeys individually known to the subjects.

Introduction

Natural categories such as "trees", "water" and "people", and the ease with which pigeons can be taught to identify colour slides of natural scenes exemplifying these categories have received much attention ever since Herrnstein and his coworkers published their experiments (Herrnstein & Loveland 1964; Herrnstein, Loveland & Cable 1976). Recently, this work gave rise to similar experiments on concept formation by monkeys (Swartz 1983; Schrier, Angarella & Povar 1984; Yoshikubo 1985). Schrier et al. (1984) examined the ability of stump-tailed macaques (Macaca arctoides) to form concepts of the categories "humans", "monkeys", and the letter "A", using colour slides as stimuli which showed exemplars of these categories. Although the authors found evidence of concept formation, the level of performance of the monkey subjects was below that of pigeons. Schrier et al. suggested that the difference between their results and those reported for pigeons may be accounted for by differences in the variety of the slides used, the salience of the objects pictured and/or the difference in the experimental procedure. Yoshikubo (1985) studied species discrimination and the acquisition of the category "rhesus monkey" by rhesus monkey subjects (Macaca mulatta). He found levels of performance similar to the results of Herrnstein and coworkers, using slides as stimuli and a procedure more similar to that used with the pigeons than Schrier et al. did. It therefore would appear that the information available in the two-dimensional stimuli is sufficient for the formation of categories. Even in young infant monkeys (Macaca nemestrina), species discrimination can be demonstrated with pictorial stimuli (Swartz 1983). The monkey and pigeon subjects in these studies had never directly seen the real counterparts of the objects whose pictorial representation they saw,

neither had most of the subjects seen any other real example of each of the categories they were tested on. The studies therefore demonstrated discrimination of categories represented by slides even in the absence of any direct experience with the three-dimensional objects. They did not attempt to show to whether and what extent the subjects perceived the slides as representations of the real objects.

The present experiments share with the studies cited the kind of stimuli used - naturalistic slides of animals rather than the more conventional physically simple stimuli - but did not attempt to replicate Herrnstein and coworkers' data. Rather, the purpose was to explore the usefulness of slides as representations of individual monkeys, familiar to the subjects. Do long-tailed macaques (Macaca fascicularis) recognize group members presented by means of colour slides? Can they match different views of the same stimulus animal? Even different body parts? Two experiments were carried out as follows, using slides of familiar and unknown conspecifics as stimuli. In the simultaneous discrimination (SD) experiment, two subjects were required to discriminate in first trials between novel slides of different stimulus animals which were either familiar or unknown. In the matching-to-sample (MTS) experiment, one other subject had to match in first trials different novel slides of the same familiar stimulus animal, with two alternatives to choose between, the negative one showing one other stimulus animal.

Method

Subjects

Two 4-year old female long-tailed macaques, Rini and Riche, and one 5-year old male, Malen, served as subjects. All three animals belonged to a naturally composed group of 40 individuals with long established social relationships. All members of this group were permanently housed together in the large indoor/outdoor compound (1000 sqm) of the monkey station belonging to the University of Zurich and were fed ad lib. three times daily. The subjects were only separated from the group for one daily session for up to 90 minutes, 5 to 7 days a week. All subjects were naive. The training of the female subjects began 1 year before the beginning of the experiments reported here. During this first year, the females were familiarized with the experimental situation by exposing them to numerous slides of familiar food and junk objects; they received no training in matching real objects to slides. The male subject did not receive this pretraining.

Apparatus

One part (about 1m³) of the indoor compound was used as experimental chamber. The experimental panel formed one wall of the chamber (Fig. 1). The panel consisted of clear plexiglas onto which a response button was attached at the lower edge of each of three daylight projection screens. Below the center screen, a feeder tube was located through which juice could be delivered automatically. A light bulb placed above the tube announced delivery of juice. Colour slides were projected from behind by three Leitz projectors which were

located behind the panel and thus partly visible to the subjects. A sound proof chamber or masking white noise were not feasible. Care was therefore taken in the programming and the arrangement of the slides to prevent projector movements which could result in cues differentiating positive from negative slides. The size of the projected slides was about 30 x 20 cm. A computer (Epson HX-20) and an associated interface controlled all equipment and recorded all experimental events, including the responses of the subjects. During their sessions, the subjects could hear other group members and look at them through small openings in one wall of the experimental chamber. Only the other subject was fully visible to the performing subject. The presence of group members was essential to a high motivation of the subjects, as was the possibility to look outside the chamber through the panel. No human observer was present when transfer trials were given.

General procedure and stimulus slides

Basically, the experiments were conducted in two phases: During the training phase, the subjects were trained to respond to one of two slides presented simultaneously as alternatives. They showed stimulus animals which were either familiar (group members) or unknown (individuals from another colony) to the subjects. The same stimulus animal was always represented by the same slide. In the subsequent transfer phase, the subjects were either tested in transfer trials on novel slides of these training stimulus animals or on familiar stimulus animals not previously used in training. During the transfer phase, transfer trials were only given during sessions in which the subject first showed criterion performance (see below) on the training trials and a high motivation to work, i.e. responded immediately when the slides were projected.

This precaution ensured that transfer trials were only presented to well motivated subjects which paid attention to the slides. In sessions where the subjects did not meet the criteria for transfer trials, only training trials were given. Only one or two transfer trials were administered per session, randomly interspersed with training trials. Some transfer trials were repeatedly presented but only performance on the crucial first trials will be reported here. Left/right position of the positive alternative in training and transfer trials varied according to a pseudo-random balanced sequence (Fellows 1967; Gellermann 1933). The subjects indicated their choice of one of the alternatives presented at the lower screens by pressing the response button beneath that slide once. Correct responses were rewarded with honey water in all trials, including transfer trials. An auditory signal marked the beginning of a trial and continued until the subject responded. The time-out interval after a wrong response was marked by a continuous tone. The light bulb above the feeder tube lit up immediately after a correct response, indicating delivery of reward.

Stimulus slides: The slides showing familiar stimulus animals were taken when the group was in the outdoor compound. They therefore varied greatly with respect to background, illumination, and the size and posture of the stimulus animal. The slides of the unknown stimulus animals were taken of the M. fascicularis colony of the University of Kassel, Germany. The slides used as alternatives in each transfer trial in both experiments were matched with respect to background, illumination, and the stimulus animal's position and posture in the picture. Stimulus animals were matched according to age, sex, and hair colour. Slides of the same stimulus animal were selected for their dissimilarity. For technical reasons only very few clearly distinct slides of

each of the unknown stimulus animals could be taken. This resulted in a small sample size (see section on the SD-experiment). Faces were projected in life size, whole bodies in much reduced size. Unless otherwise specified, slides of faces and whole bodies were used whenever suitable, subject only to the restrictions mentioned.

The details specific to the procedure used in each experiment are given in the respective sections below.

1. The simultaneous discrimination experiment: procedure and results

Procedure

Each of the two SD-subjects, Rini and Malen, received the same 6 problems. Each problem involved a novel pair of stimulus animals and a training and transfer phase and was terminated before the next began. In the first 3 problems, the positive and negative stimulus animals were familiar, in the subsequent 3 control problems, the stimulus animals were unknown. Each session consisted of 36 trials in both phases. During the training phase, the SD-subjects were trained to respond to one of two simultaneously presented stimulus animals, each represented by a single slide showing the full face. The training phase ended with the first errorless session. The slides used as alternatives in the transfer trials showed novel face views and whole views including the face of the training stimulus animals. Criterion performance during the transfer phase was an errorless sequence of 12 training trials. The transfer trials were then administered among the remaining 22 or 23 training trials, respectively. A total of 30 transfer trials were conducted on the problems with the familiar stimulus animals and 9 transfer trials on

the control problems. The use of two subjects increased the sample size in the control problems. Intertrial intervals were 10 seconds and time-out intervals were 60 seconds.

Results

In the problems in which the stimulus animals were familiar, the SD-subjects were correct on 44 of a total of 60 transfer trials ($p < 0.01$, binomial test, two-tailed, Table 1 & Fig. 2). In contrast, when the stimulus animals were unknown, the SD-subjects did not perform above chance level. Here, their overall score was 7/18 ($P > 0.05$, Table 1).

2. The matching-to-sample experiment: procedure and results

Procedure

Basically, on each trial of the MTS-experiment, the subject Riche was presented with three slides: one (the sample slide) showed the positive stimulus animal of that trial; of the two others (the alternatives) one showed an identical or a different slide of the sample stimulus animal and the second one other animal. The MTS-subject had to select one of the alternatives. If the chosen slide showed the same stimulus animal as the sample, the MTS-subject had matched correctly and was rewarded. Only group members were used as stimulus animals. The MTS-subject was first given 12 problems in which at least the face of the sample stimulus animal was also visible in the positive alternative, i.e. sample slides and positive alternatives showed overlapping body parts. Secondly, 25 problems were given in which either the sample slide

or both alternatives did not show the face(s) of the stimulus animal(s), and no body parts shown in the sample slides were also visible in the alternatives. For example, the sample slide showed the full face view of the positive stimulus animal, the matching alternative showed the front view of the lower body part of that stimulus animal and the non-matching alternative showed the same part of another stimulus animal.

One major difference between the SD- and the MTS-procedure was the multiple use of the same stimulus animals and slides in transfer trials of the latter. Also, training slides also appeared in some transfer trials. This did not, however, enable the subject to choose the correct alternative on the basis of what it has learned on preceding training and transfer trials because each stimulus animal and slide which was used more than once appeared as positive and negative alternative in random order. Thus, the subject could not associate particular stimulus animals and slides with particular reward values. Randomization of slides also ensured that combinations of slides in transfer trials gave no information about the correct choice in subsequent transfer trials. That is, the subject could not simply learn which sample goes with which alternative. Using each stimulus animal and slide only once was not only unnecessary but would have limited the sample size too much in combination with the matching requirements for the alternatives (see section on stimulus slides). The following paragraph gives the details of the procedure.

In the MTS-experiment, only the first two problems included a training phase. In contrast to the SD-experiment, training on each problem was not necessary because here the positive stimulus animal was defined by the sample slide.

These two problems were used to introduce the subject to the matching task. In the training phases of the first problem, the MTS-subject was shown the face view of a female group member as the sample, and a copy of that slide and the face view of another female as the alternatives. Thus, the MTS-subject was trained to choose the slide that was the very same as the sample. Each of the two females appeared as sample about equally often in each session. Only one slide of each female was used in training. When the MTS-subject responded in the training phase of the first problem with no more than five errors in each of three successive sessions consisting each of 20 training trials, the transfer phase of that problem began. In the transfer trials, either the sample or both alternatives or all three slides showed novel face views of the two training females. Sample slides and positive alternative were the very same in some of these transfer trials and different in others (Table 2). This allowed to test whether the subject had learned during training to match slides that were identical rather than to adopt the more generalized principle of matching any face views of the same animal. A total of 28 transfer trials were conducted on this problem. The training phase of the second problem began when all transfer trials of the first problem were completed. It was equivalent to the first training except that the two stimulus animals were males. This training phase was followed by transfer trials on slides showing the whole body of the training males. In none of the 14 transfer trials of the second problem was the matching alternative the very same as the sample slide. This condition held for all subsequent problems. From then onwards, each problem consisted of only one transfer trial which was presented only once.

On the remaining 10 problems on overlapping body parts, each sample stimulus animal appeared in this position for the first time and may have been a

negative alternative in a previous transfer trial. On the transfer trials with non-overlapping body parts, some stimulus animals were used as sample more than once.

A trial began with the presentation of the sample slide at the center screen. When 8 presses to the center response button had occurred, both alternatives were simultaneously projected onto the lower screens. All three slides remained illuminated until the MTS-subject responded to one of the alternatives. The number of trials per session varied widely (range 10 to 60) throughout the experiment on account of the varying motivation of the MTS-subject. If the MTS-subject attained the criterion performance of no more than five errors in 20 training trials during a transfer phase, the transfer trials were administered among four to five training trials, respectively. On all problems which only consisted of a transfer phase, criterion performance had first to be attained on the training trials of the second problem in each session. Intertrial intervals were 15 seconds, time-out intervals were 75 seconds.

Results

The MTS-subject responded correctly on a significant proportion of the transfer trials of the first two problems involving novel slides of faces (problem 1, Table 3, Fig. 3a) and novel slides of the whole stimulus animals (problem 2). She was not better in transfer trials in which the matching alternative was the very same slide as the sample than in transfer trials in which the matching alternative was different: (correct responses/total transfer trials) 7/8 and 15/20 ($p > 0.05$, Chi square for difference between

them). The matching rule adopted by the MTS-subject also allowed transfer to novel stimulus animals which were not previously presented as sample: the MTS-subject was correct on all remaining problems involving overlapping parts and a total of 16 familiar stimulus animals. In all of these problems, matching faces and thus mere physical matching was possible. This was excluded in the problems requiring matching of non-overlapping body parts. It was also not possible that the MTS-subject had learned which body part goes with which face from slides previously seen. Yet, the MTS-subject still attained a level of correct responding that was above chance (Table 3, Fig. 3b). This last result is most crucial to the question of recognition of the stimulus animals because it could not have been achieved unless the subject recognized the stimulus animals.

Discussion

The high proportion of correct choices of both subjects indicates that they correctly identified members of their colony presented as colour slides. When, after the first year of adaptation to the experimental situation, the present experiments using slides of familiar monkeys were introduced, it was not known whether the subject would respond to the slides with strong emotions. A strong emotional reaction, however, could well have resulted in a preference of some stimulus animals, for example close social partners and relatives, over others, or else in a reluctance to approach a potentially threatening stimulus animal such as a high ranking male, independent of the requirement of the experiment. And this, of course, would result in a large number of errors. The high proportion of correct choices suggests that the subjects' responses were not mainly based on a preference for, or avoidance

of, particular familiar stimulus animals but met the requirements of the experiments. In conclusion, then, it would appear that two-dimensional pictures of familiar monkeys can be used as representations of the real individuals in experiments requiring conceptual performance. Subsequent experiments on concepts of social relationships with the same subjects explored this possibility (in prep).

Individual recognition of conspecifics presented as colour slides was reported by Ryan (1982) for the domestic chicken (Gallus gallus). The birds, trained to discriminate slides of unknown conspecifics, were able to generalise to novel slides of the training stimulus animals in transfer trials. However, the high number of 10 different slides of the whole stimulus animals used in training seems to preclude the presentation of essentially novel slides taken from the same angles of the same stimulus animals in transfer trials. It would appear, therefore, that the transfer trials required only weak generalisation. Furthermore, since the stimulus animals were unknown to the subjects, individual recognition of the stimulus animals pictured in Ryan's study means recognition of the training stimulus animals in transfer tests on novel views rather than an unconditioned association of the picture and the real object. Trillmich (1976) found some evidence of the latter ability in one of his budgerigars subjects (Melopsittacus undulatus). The subject was trained to distinguish between slides of two familiar conspecifics and was then tested with the live birds in repeated transfer trials where the subject was rewarded for choices of the positive and the negative stimulus animal or for neither. The subject significantly discriminated between the real stimulus animals.

The ability to react to the picture of an object in the same way as to the real object pictured is regarded by Premack (1976) as a weak indication of the understanding of the representational quality of a picture. The evidence is inconclusive because it does not show whether the subject perceived the differences between the picture and the real object. The extent to which any animal species is capable of understanding the relation between an object and its pictorial representation is still unclear (Premack 1976; Premack & Premack 1983) and is a matter of some philosophical interest (Jonas 1966).

The results of the present study do not, of course, demonstrate that the long-tailed macaque understands all aspects of this relation, discussed by e.g. Jonas (1966). The results obtained are, however, in line with Malone *et al.*'s (1980) finding that rhesus monkeys (Macaca mulatta) are able to match photographs with the objects they represent and vice versa significantly above chance in a cross-modal matching task in unique transfer trials. In the cross-modal matching task, the monkeys compared the information available in the photographs to the tactile experience. In the present experiments, especially when matching non-overlapping body parts, the subjects used information about the real animals stored in memory. Monkeys, we may conclude, appear to perceive at least in part the equivalence between an object and its picture.

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Fig. 1: The experimental panel. Notations are as follows: PS: projection screen (PS1 was used for the presentation of the sample stimulus in the matching-to-sample experiment, PS2 and PS3 for the presentation of the alternatives); 3: light bulb; 4: feeder tube; 5: response buttons. Numbers outside the panel indicate lengths in centimeters.

Fig. 2: The photograph on the left shows the positive alternative used in the training of the first problem of the simultaneous discrimination experiment. A novel view of the same group member shown in a transfer trial is on the right. Originals were colour slides.

Fig. 3a: One of the sample views presented in a transfer trial of the first problem of the matching-to-sample experiment is shown on the left. The right photograph shows the matching alternative: a different face view of the same group member. b: Same arrangement as a. Sample view and matching alternative show different body parts of the same stimulus animal. Originals were colour slides.

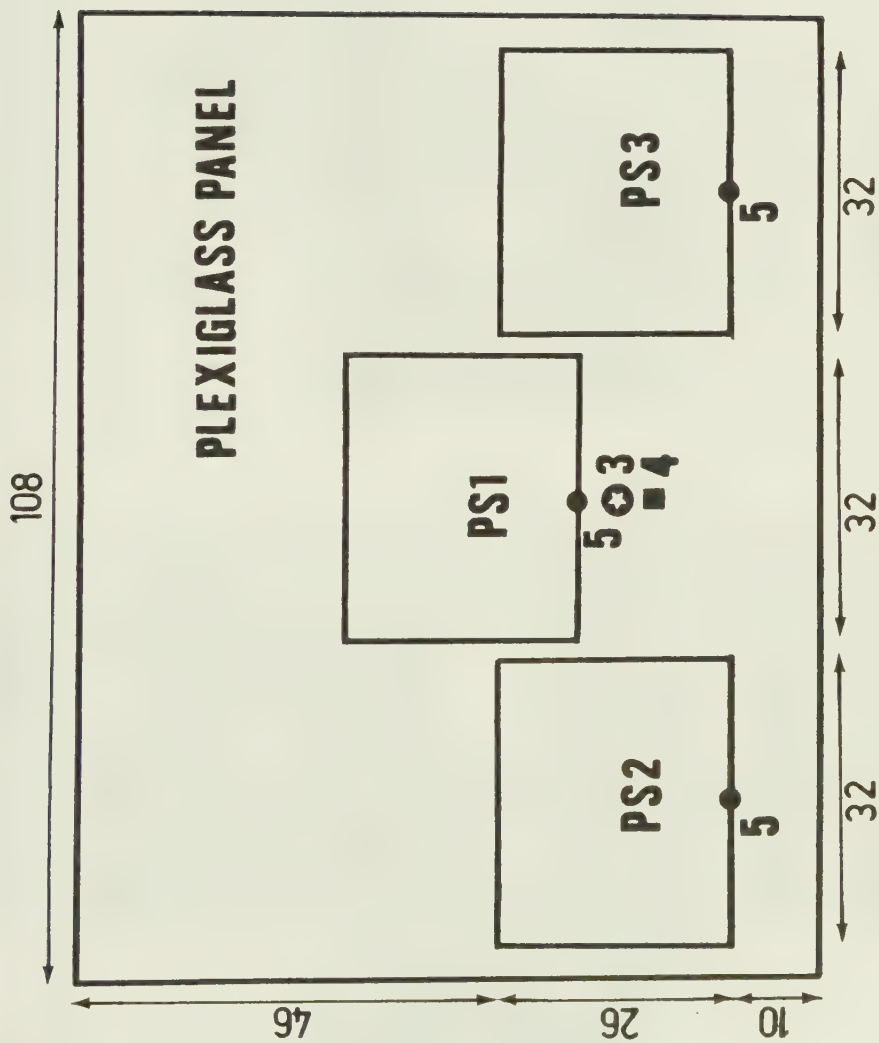


Fig. 1

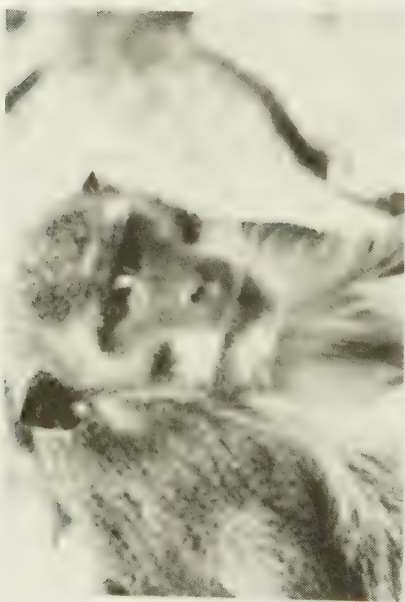
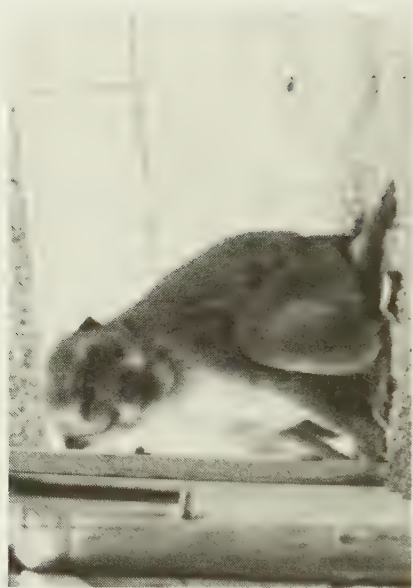


Fig. 2

Fig. 3a



Fig. 3b

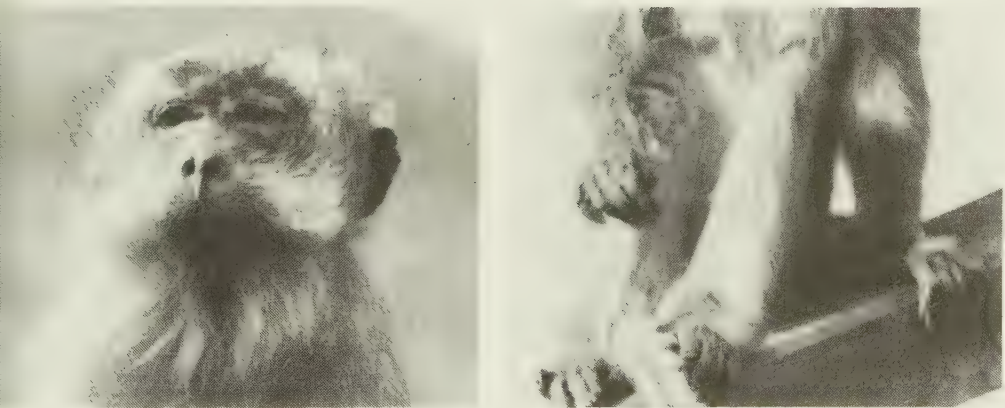


Table 1: Results of the transfer trials of the simultaneous discrimination experiment, using familiar and unknown monkeys as stimulus animals.

Problem no.	Stimulus animal							
	familiar			total	unknown			total
	1	2	3		1	2	3	
No. correct Rini	11	5	7*	23**	1	1	2	4
Malen	9	5	7*	21*	2	1	0	3
No. trials per subject	16	7	7	30	2	3	4	9

* $p < 0.05$; ** $p < 0.01$, binomial test, two-tailed.

Table 2: A summary of the experimental protocol of the matching-to-sample experiment

Problem no.	Sample	Alternatives	Stimulus animal training/transfer pos.	Sample slide/ alternative	No. trials
Overlapping body parts					
1 training	face	face			
1 transfer	face	face	same	same	8
	face	face	same	different	20
2 training	face	face			
2 transfer	face	body	same	different	7
	body	face	same	different	7
3-12	face	face	different	different	1
transfer	face	body	different	different	3
	body	body	different	different	5
	body	face	different	different	1
Non-overlapping body parts					
1-16	face	part	same	different	8
	part	face	same	different	9
17-25	face	part	different	different	8

Table 3: Results of the transfer trials of the matching-to-sample
experiment

Problem no.	Overlapping body parts			Non-overlapping body parts
	1	2	3-10	1-25
No. correct	22**	12*	10**	18*
No. trials	28	14	10	25

* $p < 0.05$; ** $p < 0.01$, binomial test, two-tailed.

Mapping a Social Concept of Monkeys

Abstract

Two adult female long-tailed macaques (Macaca fascicularis) demonstrated their ability to form concepts of social relationships by their choices of slides of group members. In a discrimination task, one subject correctly identified 14 out of 14 mother-offspring pairs in first trials, the other correctly matched views of offspring to their mothers in 20 of 22 pairs in unique trials in a matching-to-sample task. Both subjects apparently used a concept analogous to our "mother-child relationship". Thus, one mechanism underlying the complex social structure of a nonhuman primate group may be the ability of its member to categorize inter-individual relationships.

Our knowledge of the cognitive abilities of lower primates is mainly based on the performance of individually caged animals in formal problem solving tasks. Monkeys can solve cross-modal matching tasks, form abstract concepts such as oddity and sameness and may be capable of transitive inference (McGonigle & Chalmers 1977). This study investigated whether monkeys are capable of forming concepts of social relationships. In particular, can a monkey distinguish the mother-offspring relationship from other categories of dyadic social relationships? In their social interactions, monkeys differentiate between kin of different degrees of relatedness, treat higher ranking individuals differently from lower ranking ones and apparently assess some aspects of the relationship between third individuals (Cheney & Seyfarth 1985). In some monkey societies, daughters inherit maternal dominance rank relative to other females, and this status of the offspring in relation to its mother's status is recognized by other group members (Cheney 1978; Berman 1983). However, strong evidence that non-human primates form concepts about social relationships is lacking (Dasser 1985). I therefore devised a procedure which allowed socially experienced monkeys living in a naturally composed group to use social concepts in tests requiring concept attainment. Two long-tailed macaques were trained to respond to slides of pairs of members of their group or to combinations of slides portraying only one group member. The pairs and combinations of stimulus animals exemplified mother-offspring and non mother-offspring pairs. The subjects were then tested, with a different set of slides, on their responses to novel exemplars of these categories.

METHODS

Subjects

Two 5-year old M. fascicularis females, Rini and Riche, served as subjects. They were members of a group of 40 animals of a wide range of ages and both sexes with which the subjects have lived since birth. All members of this group were permanently housed together in a large indoor/outdoor compound and were fed ad libitum three times daily. The subjects were only isolated for one daily session up to 90 min, five to seven days a week. Following one year of adaptation to the experimental situation and exposure to numerous slides of familiar food and junk objects, the subjects performed singly in experiments not reported here, using slides of group members and conspecifics from another colony. The same experimental procedures were then used as in the present study.

Apparatus

The experimental chamber was one part (about 1 m³) of the indoor compound used by the group at night and in cold weather. Back and side walls were opaque, dim room light penetrated through the grid of the top wall. The experimental panel (Fig. 1) formed the fourth wall of the chamber. The panel consisted of clear plexiglass onto which a response button was attached at the lower edge of each of three daylight projection screens. A feeder tube was located below the center screen through which juice could be delivered automatically. A light bulb placed above the tube announced delivery of juice. Colour slides were projected from behind by three Leitz projectors which were located behind the panel. Because a sound proof chamber or masking white noise

were not feasible, care was taken to prevent projector movements which could result in cues differentiating positive from negative slides. The projected pictures were 30 x 20 cm large and 36 cm apart. A computer (Epson HX-20) and an associated interface controlled and recorded the experimental events and registered the responses of the subjects. The subjects could hear other group members during their sessions, and look at them through small openings in one side wall of the experimental chamber. Only the other subject in the adjacent cage could be fully seen by the performing subject. The presence of group members in the indoor compound was essential to a high motivation of the subjects, as was the possibility to look outside the chamber through the panel.

Stimulus slides

All slides of stimulus animals were taken when they were in the same complex outdoor compound used by the group during the day. The slides varied therefore greatly with respect to background, illumination, and the size and posture of the stimulus animal(s). The slides used as alternatives in a trial in all experiments were always matched with respect to part of body shown, and size of the stimulus animal(s) in the slide, and generally for body posture, background, and illumination. The faces were always visible. They showed neutral expressions and were projected in life size if no other body parts were on the slide; whole bodies were generally much smaller.

General procedure

A two-choice discrimination procedure was used in the experiment with Rini (the SD-experiment) and a simultaneous matching-to-sample procedure in the two

experiments (the MTS-experiments) conducted with Riche. Generally, an experiment consisted of two phases: during the training phase, the subjects were trained to respond to slides showing pairs of stimulus animals (SD-experiment) or single individuals (MTS-experiments). In the subsequent transfer phase, the subjects were tested in unique transfer trials on novel combinations of the training stimulus animals and on novel stimulus animals not previously used in training. During the transfer phase, transfer trials were only given if the subject showed a good performance (see below) on the training trials and a high motivation to work, i.e. responded immediately when the slides were projected. This precaution ensured that transfer trials were only presented to a well motivated subject which paid attention to the slides and to check whether they still performed well on the training trials. For although the social setting in which the experiments took place contributed much to their motivation, and possibly performance on transfer trials, the subjects were also negatively affected in their motivation and performance by intragroup conflicts and other disturbing events, e.g. a visit by the veterinarian. In sessions where the subjects did not meet these criteria for transfer trials, only training trials were given. At most three transfer trials were administered per session, randomly interspersed with training trials.

Left/right position of the positive alternative varied according to a pseudo-random balanced sequence (Gellermann 1933; Fellows 1967). The subjects indicated their choice of one of the alternatives presented at the lower screens by once pressing the response button underneath it. The slides remained illuminated until the subjects responded. Correct responses were rewarded with honey water in all trials, including transfer trials. An auditory signal marked the beginning of a trial and continued until the

subject responded. The time-out interval after a wrong response was marked by a continuous tone. The light bulb above the feeder tube lit up immediately after a correct response, indicating delivery of reward. No human observer was present when transfer trials were given. I determined the number of transfer trials at the beginning of an experiment on the basis of all suitable slides available at that time. Fewer transfer trials were conducted in the SD-experiment than in the MTS-experiment because matching slides of particular pairs of stimulus animals were more difficult to obtain than slides of single individuals. The use of slides showing faces and whole bodies was restricted only by the matching requirements mentioned above.

The details specific to the procedures and to each experiment are given in the respective sections below.

The procedure of the simultaneous discrimination experiment.

On each trial, Rini was simultaneously presented with two slides projected onto the lower screens of the panel. During the training phase, the positive alternative always showed one of five slides of the same mother and her one juvenile daughter. The negative alternative showed one of the following five pairs, each represented by a single slide: the same mother and one of two non-offspring juveniles of both sexes and of the same age as the daughter; or the same mother and a second adult female A, mother of the female non-offspring; or female A paired with the daughter of the mother; or a third adult female B combined with the daughter of A. In each session, the subject was shown two to four random combinations of these positive and negative slides and two to four negative pairs. Thus, for training, only one mother-offspring pair was used as example of the positive category of social

relationship and the negative alternatives consisted of a limited subset of all pairs that, by their sex and age, could have been a mother and her offspring. Each session throughout the experiment consisted of 36 trials. Intertrial-intervals were 10 s, time-out intervals were 60 s. The training ended with the first session with four different training trials in which the subject made no errors.

On each transfer trial, administered during the transfer phase, Rini's response to a novel mother-offspring pair and a novel negative non mother-offspring pair was tested. A total of 14 transfer trials were conducted and each was presented only once. Group members of all ages served as offspring in positive pairs, from black infants (three cases) to adults (six cases). No stimulus animal was consistently used as member of the positive or negative pair. All mothers also appeared as a member of a negative pair. Ideally, the negative pair should have matched the mother-offspring pair of each transfer trial with respect to the combination of the sexes and the age and size relationship of the stimulus animals. Because the available animals did not permit such complete matching, care was taken to avoid any consistent differences between the positive and the negative pairs other than the mother-offspring tie. Two persons, both unfamiliar with the monkeys, who independently gave their judgments, could not detect any consistent differences between the positive and negative set of slides. If the subject made no errors on the first 12 training trials of a session, transfer trials were then presented among the remaining 21 to 23 training trials.

The procedure of the matching-to-sample experiments.

Two experiments were conducted in the MTS-format, the second as a control. Basically, in both MTS-experiments, Riche was required to match mother-offspring pairs. She was presented with three slides on each trial: the mother was presented as the sample, and one of her offspring and another stimulus animal of the same sex (except for two trials) and age as the offspring were given as the positive and negative alternative, respectively. A trial began with the presentation of the sample slide at the center screen. After eight responses to the center button, both alternatives were simultaneously presented at the lower screens. All three slides remained illuminated until the subject responded to one of the alternatives. Intertrial intervals were 15 s, time-out intervals were 75 s. The number of trials per session varied widely on account of the varying motivation of the subject. At least 20 and a maximum of 40 trials were administered per session throughout both MTS-experiments.

The first MTS-experiment was conducted as follows: throughout the training phase, the subject was only shown two mother-offspring pairs and a single slide of each of these four stimulus animals. Both offspring were juvenile females. They appeared as the positive and negative alternative in random order and about equally often in each session. The training phase ended when the subject responded with no more than five errors in each of three successive 20-trial sessions. During the transfer phase, each transfer trial consisted of a novel mother-offspring pair and was presented only once. A total of 22 transfer trials were conducted. Some stimulus animals and slides were used more than once. However, the subject could not associate any of them with a particular reward value: of a total of 27 stimulus animals, 15 were used only once, and the remaining 12 changed the reward value at least once. The mothers of three pairs also appeared as offspring according to the

genealogy of the group. The offspring were adults in 10 cases. No infants were used because they rarely separated from their mothers; slides of individual infants were therefore difficult to obtain.

Immediately following the last session of this experiment, a control experiment was run to test whether matching of mother-offspring pairs was possible on the basis of physical resemblance between relatives. The same procedure and the same training stimulus animals were used as in the first MTS-experiment except that the training phase was omitted. On each of a total of 16 transfer trial, one of the original mother-offspring pairs was presented a second time but now using slides of the juvenile and adolescent offspring taken up to three years earlier. The offspring in each older slide looked distinctly different from its present state according to my assessment, and was over one year old.

RESULTS

Rini correctly identified all 14 mother-offspring pairs (Table 1 & Fig. 2). Riche correctly matched 20 out of 22 offspring to their mothers (Table 1 & Fig. 3). The incorrectly solved transfer trials were not special cases. Riche did not, however, reach significance on the transfer trials of the control experiment with the older slides of the offspring (10 correct out of 16, $P > 0.05$). The difference between this and the performance on the original pairs is significant ($\chi^2 = 4.5$, $P < 0.05$).

Thus, the subjects generalized almost completely to very diverse mother-offspring pairs although they were trained on only one or two instances of this relationship. For example, Riche generalized from two mothers and their

juvenile female offspring to mothers with adult male offspring. She did not, however, generalize to pairs with offspring at an earlier phase of their development when they looked distinctly different from their present state.

DISCUSSION

Does the excellent performance of both subjects mean that they made true judgments about mother-offspring relationships? Precisely what determined the subjects to choose the correct pairs and offspring independently of the identities of the stimulus animals involved remains to be explored, but some alternative explanations can be evaluated. If the subjects had merely learned the reward value of individual slides and/or pairs of stimulus animals, they would not have been able to generalize from training to transfer trials, nor from one transfer trial to another because they saw each pair of stimulus animals only once and, in the MTS-experiments, some stimulus animals and slides as both positive and negative alternative. Have the subjects based their choices on a single perceptual feature, or a combination of features, common to all positive pairs and stimulus animals and/or all negatives (Herrnstein et al. 1976)? That is, are the solutions of the subjects exclusively based on optical cues in the slides themselves? Attributes of the slides other than the stimulus animals, e.g. background, did not differentiate positive from negative alternatives nor were they matched in the slides of the offspring and the mother. The size and age relationship of the paired stimulus animals did not reliably differentiate the mother-offspring pairs from the non mother-offspring pairs although they may have influenced some of the choices of the subject in the SD-experiment. The failure of the two persons to detect a difference between positive and negative slides speaks, however, against a discrimination on such a basis. In the MTS-

experiment, identifying mother-offspring pairs on the basis of relative age or size relationship of the stimulus animals was not a possibility because both alternatives showed stimulus animals of the same sex, age, and size. Also, an unconditioned preference for, or a learned response to, particular stimulus animals does not account for the choices of the subjects. Could kin resemblance have been the cue? Physical resemblance among relatives can be perceived in some monkeys by an experienced human observer and the monkeys themselves are likely to be more adept at noticing it. This alternative explanation cannot be completely ruled out for the results of the SD-experiment; Rini may indeed have chosen the stimulus animals resembling each other. The explanation is unlikely to hold for the MTS-experiment because here, the subject was only successful with recent slides. The resemblance between a mother and her offspring relative to the resemblance between a mother and a non-offspring, however, does not depend on the age of slides. One might consider an experiment using unknown conspecifics as stimulus animals to be a better control. However, it is well known that the sudden introduction of unknown stimuli disrupts performance on their first presentation. I expected this generalization decrement to be less marked when at least one of the three stimulus animals (the mother) was familiar. In addition to their possible physical similarity, mothers and offspring might express their relationship when they are in close proximity, as they were when the slides were taken, by facial expressions and body postures so subtle that they go unnoticed by the human observer but not by another monkey. A mother and her offspring might look 'happier' when together than each of them does in the proximity of, say, a group member from another matriline. Again, this is a possible explanation for the result of the SD-experiments but not for those of the MTS-experiments where slides of single stimulus animals were shown. And they were taken when no other animals were nearby. It therefore would appear

that at least the results of the MTS-experiments are not satisfactorily explained by the common-feature hypothesis.

What alternative explanations are there? I suggest that the experience of the subjects with the real counterparts may have played an important role in their choices. In most monkey societies, the mother-offspring relationship, defined by the experimenter on the basis of the genetic relationship, has strong behavioural correlates, at least some of which are actually used by the monkeys to associate particular mothers and their young offspring (Cheney & Seyfarth 1980). Matrilineal kin in general associate at higher rates than non-kin in our colony, as in other monkey groups. Have the subjects based their choices on their memory of the behaviour of matriline members and non-relatives? In 11 transfer trials of the SD-task, the negative alternatives indeed were of non-kin. However, in the remaining three trials, they represented siblings. Riche correctly matched mother-offspring pairs in eight of nine such transfer trials ($P < 0.05$) where the negative stimulus animal belonged to the same matriline, e.g. was a cousin of the offspring, thereby demonstrating her ability to differentiate relations within matriline. And she correctly matched two of three offspring which also appeared as mothers. A more general explanation and the most plausible one in my opinion is that Rini and Riche chose the pair that, in their assessment, was more frequently seen than the negative pair presented in the experiments, or the one interacting in a distinctive way in the colony. The mother-offspring pair is, of course, an especially close relationship. In this sense, the choices of the subjects indicate a concept of mother-offspring affiliation rather than an insight into the genetic structure of the matriline of their group.

Pigeons in a study by Cerella (1979) generalized from a single example of a white oak leaf to novel oak leaves. How does this performance compare with the result of the present experiment? While this generalization from one instance of a concept to the whole equals the high degree of generalization of the subjects in this study, the kind of concept tested does not appear to be equivalent, nor does the mechanism underlying the generalization. One oak leaf necessarily shares common perceptual features with other oak leaves and at the same time looks differently from the non-oak leaves presented as negatives. One mother-offspring pair, however, does not share more immediately perceptible common features with other mother-offspring pairs than with other pairs of group members. Generalization from one example to the concept as a whole must therefore involve more than the perception of features common to the positive and/or negative stimulus slides. Mothers and offspring share common properties on the level of their relationships in the real world, however, and some of them must be the contents of the concepts used in this study.

Whatever the precise mechanism may involve, Rini and Riche learned to discriminate and match the training slides not by the identities of the stimulus animals - they could not have solved the transfer trials had they done so- but they used a more abstract category analogous to our concept of "mother-child relationship".

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Table 1: Results of the discrimination and matching-to-sample experiment.

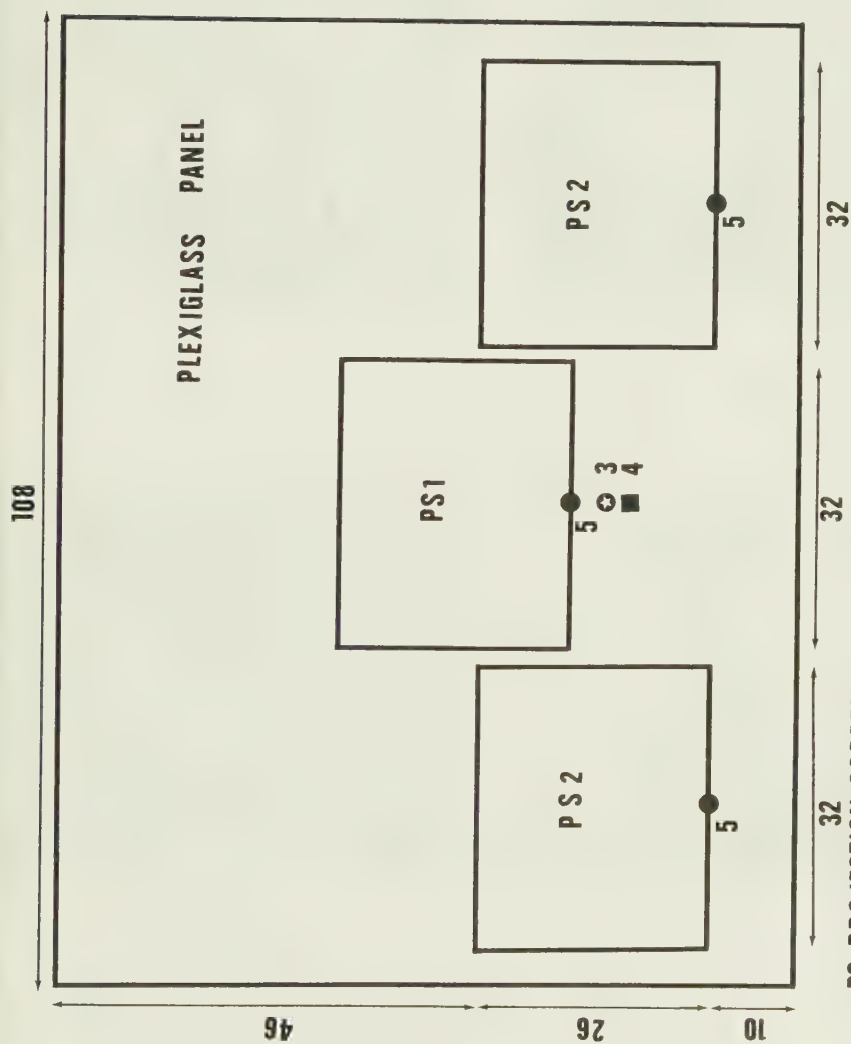
	Subject	
	Rini	Riche
No. correct	14***	20***
No. trials per subject	14	22

*** $p < 0.001$, binomial test, two-tailed.

Figure 1. The experimental panel. PS1 was used for the presentation of the sample stimulus in the matching-to-sample experiment, each PS2 for the presentation of one alternative. Numbers outside the panel indicate lengths in centimeters.

Figure 2. One picture of the mother-offspring pair used in training in the discrimination experiment is given on the left, a novel mother-offspring pair used in a transfer trial is on the right. Originals were colour slides.

Figure 3. The picture of a mother presented as the sample in a transfer trial of the matching-to-sample experiment is on the left, the right photograph shows the matching view of her offspring. Originals were colour slides.



PS: PROJECTION SCREEN
 3: LIGHT BULB 4: FEEDER TUBE 5: RESPONSE BUTTON

Fig. 1

Fig. 2



Fig. 3



Dominance: A monkey's view

I report here the result of an experiment which tested whether a monkey (*Macaca fascicularis*) classifies pairs of group members according to the asymmetry which we call dominance. Dominance relationships are inferred from agonistic interactions which can be directly observed. Relationships, however, are abstractions. Do animals, in particular nonhuman primates, recognize aspects of relationships? Monkeys not only react to agonistic behaviour directly but also remember the outcome of agonistic interactions involving themselves as well as between other individuals and they adjust their behaviour accordingly (e.g. Anderson & Mason 1974). However, even complex social events are not necessarily based on insight into social relationships: the monkeys may be responding to social behaviour rather than to the relationship (Altmann 1981). Strong evidence that monkeys actually form concepts of social relationships is still lacking (Dasser 1985) though the results of the experiments by Cheney & Seyfarth (1985) are suggestive. Altmann (1981) proposed a scheme to test whether a subject is able to recognize transitivity as a property of dominance relationships when given incomplete information on the relative dominance of unknown conspecifics.

In the present experiment, pairs of group members were presented to the subject, a female long-tailed macaque, in the form of colour slides. Basically, the subject was taught in a training phase on two pairs of group members to choose the slide of the dominant member. She was then tested in a transfer phase on her response to novel pairs of group members.

The subject, Rini, was the 5-year old beta female of a socially living group of 40 individuals with which she had lived all her life. She was only

separated from the group for one 30-min session a day, five to seven days a week. Prior to this experiment, the subject had participated in discrimination experiments where she had correctly identified individual group members on novel slides giving various views of the individual but had failed on novel slides of unfamiliar conspecifics from another colony after training on an equal number of training slides of group members and strangers.

The experiment was conducted in one part (about 1 m³) of the indoor compound used by the group at night and in cold weather. The experimental panel consisted of clear plexiglas. The slides were projected from behind onto two daylight projection screens. The projected pictures were 30 x 20 cm large, 36 cm apart and 10 cm above the floor. A feeder tube was located between them through which sugar water could be delivered automatically. A light bulb above the tube announced delivery of reward. A response button was attached at the lower edge of either screen. All equipment and the responses to the slides were automatically controlled and recorded. During the session, the subject could hear and see other monkeys but no observer was present.

All slides were taken in the same complex outdoor enclosure where the subject spent the days with the group. Faces showed neutral expressions and were projected in life size; whole bodies were generally much smaller.

A 2-choice simultaneous discrimination procedure was used. The subject was presented with two slides on each trial. During the training phase, each slide portrayed the face of one of three group members, all adult females which were several years older than the subject. The female lowest in rank was 5 years older than the two others which differed in age by only two days. In each session, the subject was confronted with all three females, each represented

by a single face view. In each trial, the second ranking female was either paired with the top ranking, or with the lowest ranking one. Both kinds of trials were presented in a pseudo-random order and an equal number of times during each session. The dominant member of each pair was arbitrarily defined as the rewarded positive one. Thus, the middle ranking individual was equally often positive and negative. The same three individuals and slides were used throughout the training phase. The subject's responses consisted of a single press to the button underneath the slide chosen. Each session throughout the experiment consisted of 36 trials. The training phase ended with the first session in which the subject made no errors.

During the transfer phase, the subject was confronted with transfer trials on which slides showing novel pairs of male and female group members of all ages but no infants were presented. Transfer trials were, however, not conducted unless the subject first correctly solved 12 training trials which were the same as in the training phase. Only one or two transfer trials were then administered per session, randomly interspersed with the remaining 23 or 22 training trials. A total of 28 transfer trials, i.e. novel pairs, were conducted and each was presented only once. The slides of each of these trials were always matched according to part of the body shown, i.e. face or whole body, and size of the monkey in the slide; and generally for body posture, illumination, and background. Only group members of the same sex were paired and whose relative dominance position was known to the experimenter from data on fear grins. Simply learning the correct individual was excluded by using an individual only once (14 individuals) or by choosing its dominance position according to a random order (16 individuals), subject to the restriction that none appeared more than three times. As a result of this randomization, 10 of the 16 individuals changed their rank position at least once.

All correct choices were rewarded. Left/right position of the positive slide varied according to a pseudo-random balanced sequence (Gellerman 1933; Fellows 1967). An auditory signal marked the beginning of a trial and continued until the subject responded. The time-out interval (60 s) after a wrong response was indicated by a continuous tone. The intertrial interval was 10 s. Cues stemming from the equipment (e.g. projector movements) which could have helped the subject distinguish positive from negative slides were avoided.

The following results were obtained: in the transfer trials, the subject chose the positive dominant member of five pairs and the subordinate of 23 pairs. This performance is far from that expected by chance level ($P < 0.01$, binomial test, two-tailed). The result is consistent with the notion that the subject's choices were based on the dominance relationship of the individuals but she obviously favoured the subordinate. This resulted in her being not rewarded in most transfer trials but the negative reinforcing effect of this was probably low since transfer trials constituted less than 6% of all trials in a session.

Were the choices of the subject based on an asymmetry other than the dominance relationship (or its monkey analogue)? Neither age nor weight reliably differentiated the positive from the negative individual: the dominant was the older in only 16 of the 28 pairs, the heavier in only nine pairs and the lighter in nine. Of the remaining 10 pairs, relative weight was unknown and could not be estimated from the appearance of the monkeys. Neither of these asymmetries explain Rini's five choices of the dominant member. Weight and/or age did not discriminate dominant from subordinate individuals because juvenile males and females of all ages ranked immediately below their

mothers. Did the subject simply choose her preferred partners? This can best be answered by looking at her choices of those 10 group members which appeared in both positions. She showed no consistent preference for, or avoidance of, particular individuals: eight individuals were both rejected and chosen, respectively, on different transfer trials.

I cannot offer an explanation for the preference of the subject for the subordinate member of a pair. As beta female, Rini ranked above all but one of the 18 females presented on the transfer trials, though only above at most three of the 12 males (her position relative to two of these three males was unsure). Fear of approaching the slide of the dominant individual does therefore not plausibly account for her choices. Nor does an egocentric discrimination by the subject between individuals ranking above and below her explain her choices. It would appear then that in the experimental situation the subject used a perceived asymmetry between the live animals corresponding to their dominance relationship as perceived by the observers.

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Mother-offspring pairs, siblings, and matriline membership

Monkeys are able to identify the mother-offspring pairs among their group members indepently of the individuals involved. Evidence for this came from the performance of the subjects in the mother-offspring experiment. The most plausible explanation was that the subjects chose the 'stronger' of the two relationships presented to them on each transfer trial on the basis of the behaviour of the real mother and her offspring. If this interpretation is correct, picking out the mother-offspring pair may have been an easy task because two-thirds of all negative pairs summed over both subjects were composed of group members of different matriline whose affiliations were known to the experimenter from proximity data, agonistic interactions and grooming frequencies to be weak in comparison with that of the mother-offspring pairs. Behavioural associations of individuals are generally stronger within matriline than between matriline. One would therefore expect that the subjects would find it more difficult to distinguish mother-offspring pairs from other pairs composed of group members of the same matriline. However, evidence from the mother-offspring experiment speaks against this: one subject, Rini, was correct on three of three such "difficult" transfer trials, the other, Riche, made only one error on nine transfer trials. It seems, then, that mother-offspring pairs can be distinguished from any other dyadic relationship.

What of other categories of affiliation? Does a monkey's concept of social relationships allow for a categorization going beyond the distinction mother-offspring vs non mother-offspring? A more exacting task was presented to Rini to determine whether she is capable of differentiating maternal sibling pairs from other pairs of group members, in particular from pairs of individuals

belonging to one matriline, not necessarily the same as that of the sibling pair. As in all previous experiments, the pairs were presented using colour slides.

Each pair of siblings used in the experiment was paired with an exemplar of one of the following negative pairs to give three types of discriminations: mother-offspring pairs (type 1 discrimination), pairs of matriline members otherwise related (type 2 discrimination), pairs of unrelated group members from different matrilines (type 3 discrimination).

Method

The same subject, Rini, and the same procedure were used in the present experiment as in all preceding simultaneous discrimination experiments. It followed the experiment on the concept of social dominance. On each training trial, Rini was confronted with either a type 1 or type 3 discrimination. The following training slides were used: as in the mother-offspring experiment, only one example of the positive category was presented, namely one pair of adult sisters represented by two different slides. As negative alternatives served two different slides of a mother and her juvenile son, and two slides showing one of the sisters once with an unrelated female and once with an unrelated male. On each session of 36 trials, each of the two types of discrimination appeared about equally often. On each transfer trial, Rini was tested on one of the three types of discriminations on non-training pairs. A total of nine transfer trials of each type was presented. The types were presented in random order. The use of the transfer trials differed from the previous experiments in two respects: firstly, the slides of the transfer trials were not all taken before the beginning of the experiment and the

predetermined number of 12 transfer trials of each type of discrimination had to be reduced to nine because pictures of specific pairs were more difficult to obtain than expected. This decision was taken when only about four transfer trials of each type were completed. I am stressing this point because it turned out that the significance of one result was reached only with the correct choice on the very last transfer trial (see result section). Secondly, using the same subject in several experiments involving group members as stimulus animals carries with it the disadvantage that some or all individuals and pairs and, at a higher level of abstraction, social categories have a history as positive and/or negative stimulus animals or stimulus categories. They can therefore not be presented as truly novel. For example, in the mother-offspring experiment, Rini was rewarded for choosing mother-offspring pairs whereas pairs of unrelated individuals were negative. Thus, both the categories and the pairs used as exemplars thereof may no longer be neutral with respect to the reward expectation of the subject. It is therefore important to know the reward history of the stimulus animals and categories involved in the present experiment: on the level of the category, mother-offspring pairs were positive in the mother-offspring experiment and negative in the present one, and pairs of unrelated individuals were always negative. In spite of the present training on the one negative mother-offspring pair and the long interval between the experiments (> 6 months), an influence of the mother-offspring experiment seemed plausible. Care was therefore taken to reduce it as much as possible: for the most interesting type 2 discrimination, all but one positive and all negative pairs were novel, i.e. were never previously used. The one exception was used once as a negative pair. Thus, choices on type 2 discriminations were not influenced by previous experience. In the type 3 discrimination, such an influence was possible on the level of the category 'unrelated individuals' but not on the level of the

pairs because all negative pairs as well as all sibling pairs were novel. In type 1 discriminations, neither the categories nor all pairs were novel: six of the nine mother-offspring pairs were previously used in transfer trials in the mother-offspring experiment. Also, six sibling pairs which were used twice in the present experiment were used the second time in type 1 discriminations. Rini's choices in these discriminations will therefore have to be interpreted in the light of these reward histories. An effect of previous exposure on the level of the slides need not be considered because all of them were novel.

Results

The overall result, 19 correct out of 27 transfer trials ($P=0.05$, Tab.1), suggests that Rini used a rule of categorization, a concept, which enabled her to pick out the sibling pair. She was hardly ever wrong unless the negative pair was a mother and her offspring. It seems that in spite of the training on the negative mother-offspring pair in the present experiment, Rini still stick to her initial training on the positive mother-offspring pairs.

The perfect performance (100% correct) on type 3 discriminations did not surprise in view of the results of the mother-offspring experiment where all but one of 24 pairs of unrelated group members summed over both subjects were correctly rejected. It seems that the subjects easily discriminated between two categories of relationships if one of them involved group members from different matriline.

The most interesting discrimination of this experiment was that of type 2, the discrimination between the two categories of within-matriline relationships, sibling relationship vs matriline membership. With only one error in nine

transfer trials, Rini passed what was probably the most demanding of her tasks. She was able to pick out the sibling pair regardless of the composition of the negative pair: four pairs showed aunts (uncles) and nieces (nephews), two pairs exemplified cousins, one showed a grandmother and her granddaughter, another one a great-grandmother and her great-granddaughter. The one pair preferred to a sibling pair was a great-aunt and her great-nephew. This is quite impressive but, as was mentioned in the method section, the significance hinges on the correctness of a single choice, for although eight correct out of nine is significant, seven out of nine is not. In conclusion, it would appear that here as in the mother-offspring experiment, Rini differentiated between different categories of affiliation. Her categorization rules (her concepts) are analogous to the respective human concepts.

Discussion

Kin recognition in the sense that related individuals are distinguished from unrelated ones is a widespread phenomenon in animals. It usually manifests itself in preferential associations of relatives. There is another type of kin-recognition which was described as non-egocentric by Cheney and Seyfarth (e.g. 1985) and which thus far was only suggested by a few primate studies, namely the discrimination of kin-associations between others. For example, Cheney and Seyfarth (1980) showed that vervet females associated screams of particular juveniles with particular adult females, their mothers.

It is with this latter type of discrimination with which the present experiment is concerned. And although the discrimination involved genetically defined categories of relationships, it did not aim at showing whether the subjects recognized the genetic relationships between group members but rather it attempted to show whether monkeys have concepts of social relationships.

The results of this and the preceding experiments suggest that monkeys indeed form such concepts. I do not wish to imply that the subjects formed these concepts during the experiment. This seems extremely unlikely given the small number of training examples and the high degree of generalization asked for in the transfer trials. (See discussion of the mother-offspring experiment). In fact, there seems to be no way of teaching a monkey the concept of social relationship with the method used. And perhaps there is no way at all. All I tried to do in this and the preceding experiments on social relationships was to set the stage for the demonstration of concepts possessed by the subjects prior to any experiment.

The experiment do not show, of course, that humans and monkeys share the same social concepts but merely that certain human-defined concepts have an analogue in the monkey's view of his social world.

References

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Tab. 1. Results of each type of discrimination

	Pair of siblings vs		
	mother-offspring pair	pair of matriline members	pair of unrelated group members
No. Correct	2	8 *	9 **
Total transfer trials	9	9	9

* $p < 0.05$; ** $p < 0.01$, binomial test, two-tailed.

Curriculum vitae

Am 6. März 1953 wurde ich, Verena Elisabeth Dasser, Bürgerin von Thalwil ZH, in Zürich geboren. In Küsnacht und Herrliberg besuchte ich die Primarschule. Nach der Sekundarschule in Herrliberg trat ich 1969 in das Lehrerseminar Küsnacht ein, wo ich 1973 mit dem Abgangszeugnis abschloss. Im folgenden Jahr besuchte ich das Oberseminar des Kantons Zürich und erhielt im Frühling 1974 das Primarlehrerdiplom. Im Herbst 1974 immatrikulierte ich mich an der Philosophischen Fakultät II der Universität Zürich. Im Herbst 1979 schloss ich meine Studien mit dem Diplom in Zoologie ab. Für ein Jahr wechselte ich an die Universität von Sussex, England, um mich in Evolutionstheorie weiterzubilden. Vom Herbst 1980 bis Frühling 1986 arbeitete ich, neben meiner Dissertation unter Leitung von Prof. H. Kummer, als kantonale Halbassistentin an der Abteilung für Ethologie und Wildforschung der Universität Zürich. 1986/87 war ich ein Jahr lang Nationalfonds-Assistentin. Während der letzten vier Jahre leitete ich jeweils im Rahmen meiner Halbassistentenz als Lehrbeauftragte das Ethologie-Mittelbaupraktikum.

Während meines Studiums besuchte ich Vorlesungen und Kurse folgender Dozenten der Universität Zürich: Bächli, Bachofen, Batschelet, Biegert, Birnstiel, Briegel, Brun, Burla, Chen, Christen, Claude, Cook, Eugster, Gasser, Hohl, Humbel, Jungen, Kägi, Kubli, Kummer, Nievergelt, Nöthiger, Oswald, Rast, Rieber, Tardent, Turner, Wanner, Wehner, Ziswiler.

